SHELLFISH INVESTIGATION - PROGRESS REPORT #15

December 9, 1948

Offshore Crab Shedding - 1948

Regulations setting closed seasons for crab fishing in the offshore waters of the State were promulgated following a public hearing July 22, 1948. Tentatively the Oregon coast was divided into two areas: Area I - from Cascade Head north; and, Area II - from Cascade Head south. These areas were to be closed to commercial fishing upon two week's notice after the over-all condition of the crabs in each area exceeded ten per cent soft shell.

A set of criteria for determining over-all soft-shell condition was drawn up as reported in the August 6 report on Area II. Briefly these were as follow:

1. Determination of number and location of all pots fishing in each area.
2. Grouping of these pots into natural local areas.
3. A. Determination of soft-shell condition in each local area by as intensive sampling as possible.
   B. The above to be determined by considering total numbers of soft legal-size male crabs found as against the total legal-size males without any breakdown or averages between separate strings of gear.
   C. The maximum time any set of figures may be considered valid for purposes of combination with other figures of the same local area being defined as not greater than the average length of fishing time between lifts.

4. A. Expression of soft-shell condition in each local area in terms of "soft-pots", this being the same percentage of pots present as the percentage of soft-shell crabs found there.

B. The total of "soft-pots" in all sub-areas as against the total number of pots fishing in the entire area to then give the over-all percentage of soft-shell crabs for the entire area.

Area II

An intensive set of samples during the week of July 31 through August 5, 1948 resulted in the following data:

Crab Boats Operating and Number of Pots Fished

Newport	5 boats	430 pots
Winchester Bay	1 boat	200 pots
Coos Bay	4 boats	364 pots
Port Orford	7 boats	285 pots
Totals	17 boats	1,279 pots

Crab Pots Out By Area

Alsea (north of river)	243 pots
Alsea (south of river	103 "
Cape Perpetua (north of Cape)	44 "
Heceta Head	40 "
Umpqua (around mouth of river)	309 "
Coos Bay (off Bay proper)	255 "
Cape Blanco (north of Cape)	75 "

Crab Pots Out By Area - cont.

Elk River ———————— 60 pots

Rogue and Euchre Rivers ——— 150 "

1,279 pots

Soft-Shell Condition

	Dates Exam.	Pots Exam.	Pots Out	Per cent soft-shell	Soft pots
North of Alsea -	July 31	43	243	14.1	34
South of Alsea -	July 31 - Aug. 3	101	103	10.4	11
Cape Perpetua -	Aug. 3	44	44	10.3	6
Umpqua -	Aug. 5	105	309	10.4	32
Coos Bay -	Aug. 3 - Aug. 5	31	255	53.7	137
TOTALS		324	954	——	220
Over-all condition				23.1	

All areas sampled were at least ten per cent soft-shell.

Reports from these and other fishermen gave no reason to doubt the percentages found.

Reports indicated areas not sampled to be running the same magnitude soft as those above.

Even if all other areas had been 100 per cent hard (virtually impossible) the over-all area condition would still have exceeded ten per cent (17.2 per cent).

Accordingly the Commission declared a closed season in Area II, effective August 26, 1948.

It might also be noted that the fishermen were bringing their gear in at this time regardless of the pending closure, it being calculated that about 500 pots were scheduled to come in by August 14 with all but about 100 to come in as soon thereafter as possible.

A follow-up sample was made August 17 covering 57 pots south of Alsea to Cape Perpetua. This trip showed 7.2 per cent of the crabs to be soft-shelled. Reports were also obtained of the catches on two trips made August 23. Thirty-two pots south of Alsea gave a soft-shell figure of 7.7 per cent by the fishermen's count, and 25 pots off Cape Perpetua gave ten per cent soft-shell by the fishermen's count. However, these last trips' figures are subject to question on several points. First, it is hard for the fishermen to keep an accurate record of the numbers of soft crabs found, and second, their grading is frequently subject to error due to the rapidity with which they must work.

In any event it appears possible that the magnitude of soft crabs did not change appreciably during the two weeks until actual closure of the area. Most of the fishermen reported such as being the case, claiming that the crabs actually "picked up" during that time and were getting better rather than worse.

However, there seems to be little doubt as to the condition of the crabs immediately after closure of the area. At our request one of the otter trawl skippers, Gus Christenson on the "Hero", had been keeping a count on the crabs he brought up in his drag net from the first part of August on. Through the month of August he reported nothing but hard-shelled crabs. On two occasions he brought the crabs into the dock where personal examination verified the condition. His catches averaged up to two dozen crabs per day. The week of August 30 he reported a "few" soft-shells but was not very definite. However, on September 5 and 6 dragging in 32 fathoms off Yaquina Light yielded only 11 hard crabs out of 12 dozen, or about 90 per cent soft. On September 11 two tows in 27 fathoms from Beaver Creek to Yaquina Light gave no hard crabs in a total of 6 or 7 dozen,

or 100 per cent soft. On September 12, a two-hour tow in 26 fathoms in the same area as above gave four hard crabs out of a total of five dozen, or 94 per cent soft. These were reportedly all very large, very soft crabs. Although he ceased counting at this time he reported the same magnitude of soft crabs to exist on through September so it was not a case of a few unusual day's results.

Thus despite the apparent last minute improvement in condition of crabs caught in commercial pots the middle of August it still appears that the closure date for this area at least north of Coos Bay was correct for 1948; that by the first of September the bulk of the crabs were soft-shelled.

Although apparently somewhat later, this agrees in general with the few figures obtained in 1947 when on August 1 the Alsea area ran 48 per cent soft with Yachats (Cape Perpetua) running 0.4 per cent soft. Reports from the fishermen for that summer indicated in general a larger number of soft-shells during August. Samples of September 18, 1947 gave 84 per cent soft off Alsea and 75 per cent soft off Ten Mile (south of Cape Perpetua).

The one disconcerting note in the summer's results was the extremely soft condition (54 per cent) of the crabs off Coos Bay proper, while the other sub-areas were just reaching ten per cent soft. This could be one of two things, or a combination of both; the results in a peculiar localized spot, or, the starting in of a general area to the south which softens up earlier. It might be noted at this point that the closing date for the Northern California fishing off Eureka has been set by that state as August 30 with the San Francisco area closing August 15. Unfortunately it has not been possible as yet to obtain any figures for the Port Orford area.

However, the only assumption that can be followed at the moment is that the Coos Bay (and northern) data is reasonably correct. On the basis of the foregoing biological data it does not seem proper to allow these soft crabs here to influence and advance the closing date of fishing on all the remaining crabs from the Umpqua to Newport regardless of what the reason for their softness may be.

Accordingly it is believed that when these regulations come up for review the Commission should consider the possibility of creating a new area in the south which would include the soft group of crabs found off Coos Bay. Then if this is found to be a mere local peculiarity both of the new areas (the present Area II) could still open simultaneously or very nearly so; whereas if it does reflect an earlier softening of the crabs farther south the lower area could, as it should be, be determined primarily on the basis of sampling from the Port Orford area. It is therefore suggested that the present Area II be divided into two areas, one from Cascade Head to the vicinity of Ten Mile Creek midway between the Umpqua and Coos Bay, with the other area extending from there south to California.

The foregoing might cause some enforcement problems due to the Coos Bay fleet then fishing in two different areas, one off the Umpqua and Tahkenitch with the other south to Tower Rock. If the resulting complications should be felt to outweigh the biological factors an alternative method would be to divide the present area II in the vicinity of Siltcoos, north of the Umpqua. For the times of the year in question this would then place all Coos Bay fishing in the lower of the two area.

Still a third possibility would be to leave Area II as it now exists until further data can be obtained. In any event considerably more data is needed on the crabs south of Cape Arago.

Area I

Sampling in Area I was begun August 13. For the week of August 13 - 20, the following was found:

Crab Boats Operating and Number of Pots Fished

Astoria	3 boats	305 pots
Tillamook	4 boats	833 pots
TOTAL		1,138 pots

Crab Pots Out By Area

Washington Waters:			
	Long Beach	30 pots	
	Peacock Spit	165 pots	
	TOTAL	195 pots	195 pots
Oregon Waters:			
	Off Col. R. (so. side)	110 pots	
	Rockaway-Neahkanie	148 pots	
	Bay Ocean	88 pots	
	Cape Mears-Cape Lookout	222 pots	
	Cascade Head	375 pots	
	TOTAL	943 pots	943 pots
		GRAND TOTAL	1,138 pots

Soft-Shell Condition

	Dates Exam.	Pots Exam.	Pots out	Per cent soft-shell	Soft pots
Columbia River	Aug. 13	64	110	0.5	1
Rockaway	Aug. 19	48	148	30.4	45
Bay Ocean	Aug. 19	58	88	39.3	35
Cape Lookout	Aug. 18	88	222	15.6	35
Cascade Head	Aug. 20	100	375	10.3	39
Totals		358	943		155
Over-all Condition				16.4	

The preceding considers only those pots fishing in Oregon waters. If the pots fished by Oregon boats in Washington waters are included the figures for the Columbia River are changed to a total of two soft pots out of 305 fishing. This then gives an over-all condition of 13.7 per cent.

It will be seen that in any event the over-all condition exceeded ten per cent soft shells, due entirely to the large block of crabs being fished on by the Tillamook fleet.

With the Astoria crabs still less than one per cent soft it was feared that a closure of the entire area because of the Tillamook crabs would have caused serious economic and interstate repercussions in the Astoria area. In view of the delicate interstate relationships involved; the fact that the Astoria crabs were still all hard; and the fact that the Tillamook boats were rapidly bringing their gear in at a rate such that very little would be left out after another two weeks anyway, it was therefore jointly decided by the Administration and Research Divisions to hold the season open for at least a while longer to see what might develop.

It was not possible to continue sampling out of Tillamook since in another week all gear remaining out was that of a single boat which refused to cooperate any further in the matter. However, the sampling was continued out of Astoria with results as shown:

Aug. 26 —	South Side ————	53 pots exam.	1.9% soft
Sept. 10 —	South side, by jetty ————	40 " "	7.2% "
Sept. 10 —	South Side, along beach ———	34 " "	0.6% "
Sept. 10 —	South Side TOTAL ————	74 " "	5.0% "

Sept. 11 —	Peacock Spit ————	31 pots.exam.	0.8% soft
Sept. 11 —	Off Long Beach ————	24 pots exam.	2.2% soft
Sept. 25 —	Peacock Spit ————	21 pots exam.	0.7% soft

In the meantime two of the boats had brought in all their gear by September 10, leaving only one still fishing. On September 25, the last day sampled, the last of this gear was brought in. However, when this boat brought in the last of its pots from the South Side on September 21-23 it reported that the pots had suddenly filled with soft shells to the extent of 30 to 50 per cent. Up to about September 20 they had reported the same magnitude of soft shells as encountered around September 10, namely perhaps five per cent but it had appeared as if at the very last the peak of shedding had built up, perhaps accentuated by a "wave" of soft-shells "moving-in".

Since there were no longer any pots whatsoever fishing (having been brought in primarily because of low catches rather than condition of crabs) in this area, and since there seemed no reason to question the reports of the men bringing in the last gear, the over-all condition of the crabs was declared as exceeding ten per cent on September 27. The Commission therefore declared a closed season for Area I, effective October 10, 1948.

One conclusion stands out over all others from the foregoing, namely, that the nature of the crab stocks as fished on in the Astoria and Tillamook areas differ too greatly in terms of time of soft-shell season to be included in the same area. During the middle and latter part of August, 1948, the crabs off Tillamook not only ran about 30 per cent obviously soft-shell but observation of the catches showed that up to an estimated 20 or 25 per cent of the crabs actually landed were

new-shelled crabs that were already hardening up, some of which still appeared too light in weight to warrant use from the standpoint of maximum utilization. In contrast, at Astoria the crabs being caught were at least 95 per cent old-shelled hard crabs for approximately another month. Due to economic and sociological factors this combining of the two areas into a single regulatory area for 1948 had the ultimate effect of giving no effective closed season for Tillamook. Rather it was necessary to sanction, by inability to close, the fishing of soft-shell crabs straight through their entire peak season in this area, and in this area alone.

Admittedly considerable more data is needed here to fully explain such an apparent wide deviation from the normal coastwise conditions. However, this one year's figures alone are felt sufficient to justify breaking the present area I into two new areas; the one extending from the mouth of the Columbia to Tillamook Head, the other from Tillamook Head to Cascade Head.

Beach Width Studies

Another method of approach towards the study of crab sheddings was a short examination of shed crab backs cast upon the beaches both outside on an open beach and within a protected area, a bay. The areas chosen were immediately within the Newport area, the bay area being on the south side of Yaquina Bay and being bounded by the bridge on one end and extending eastward (up bay) 470 yards. The other area chosen was south of Yaquina Bay on an open beach extending 650 yards to the south and 950 yards to the north of the mouth of Thiele Creek, known as Thiele Creek Beach.

One sample measurement was taken from each area, time not permitting daily or weekly sampling.

Figure 1 shows the distribution of the backs measured in the Yaquina Bay area heretofore defined. This sample included 199 measurements having a mean of 134.7 mm with two definite peaks, one at approximately 130 mm and the other at about 153 mm.

As a comparison, a frequency graph was made of all soft male crabs (#2's) from a commercial bay crabber's catch, this trip being accompanied by a biologist of this station. Difference in time was 23 days between the two samplings which was believed to be a reasonable amount of time to allow the newly shed crabs to harden their shells and regain their vitality. It has been found in the Newport lab aquaria that immediately following shedding a crab does not actively move about and it is not until a number of days later that he will take food. Consequently there would be some time lapse between shedding and the time of entering the crab rings of commercial fishermen.

The number of crabs in the soft condition from this particular trip was 261, this number being plotted according to size on the frequency graph figure 2. It has been previously found that a sample of 250 specimens and over generally gives a representative picture, 500 being most reliable. Due to the irregularity of the August 18 sample it was decided another sample should be plotted for the same area and this is found in figure 3 being taken September 30, 1948. This sample of 209 specimens also showed a great amount of irregularity which indicates the probability that our sample was not large enough for the conditions and the time of year taken.

A sample of crabs taken covering such a wide range of sizes can be affected in many ways, some of these which might be:

(1) Selectivity of the crab rings due to the size of mesh used. That is, the smaller crabs, 100-125 mm and under can escape through the mesh while the ring is being raised, thus giving a non-normal sample for the immediate population.

(2) Large feeding crabs tend to drive away the smaller crabs, this also affecting the sample. This has been noted upon feeding crabs in captivity. Larger crabs will tend to fight the smaller ones whenever food is made available.

(3) Duration for the time of sampling has its effects. Where pots are left to fish for four and five days the rings are fished only during a tide change which is at most six to eight hours. A short period of sampling may be subject to influxes of certain portions of populations, whereas a long period of sampling will tend to get an over-all picture of the population(s) present.

(4) Our figures indicate a differential in time of shedding between instars as well as within. It is entirely possible then to see how a sample could be skewed by sampling during times or peaks of sheddings when certain portions of a population may be rapidly shedding and other portions may not.

Looking at the frequency graphs again it may be seen that the two soft-shell graphs show the same magnitude of location of modes as the shed-backs graph. It is believed that the shed crab backs give more of a cross-section of the population and therefore would be a more valid sample than the soft shells. This in part is due to lack of selectivity, a longer time element and no differential in size of crabs.

In figure 4 is shown a frequency graph for the crab backs recovered in the Thiele Creek Beach area. Because there were no number two crab samples available for comparison not much more than a passing word can be said of this sample. This 380 observation sample shows one definite

peak only, that being around 105 mm. It is an interesting comparison to look at the over-all average width of the Thiele Creek Beach sample as against the mean width of the Yaquina Bay sample, the Bay sample showing a 22.5 mm larger mean than the open ocean sample.

From the foregoing discussion it might be possible, through a systematic periodical check of shed-crab backs along the closed as well as open beaches during the soft-shell season, to have a good method of checking of shedding activities of crabs. Setting off definite known areas to be checked at regular intervals might be of great value in studying shedding areas and shedding times of the commercial crab to say nothing of growth studies and its many ramifications.

Point-to-Point vs Shoulder-to-Shoulder Measurements

There was much talk and criticism when the recent size limit on ocean crabs went into effect. Criticism was based mainly on method of measuring and relationship between the two generally employed methods, i.e., point-to-point measurement and shoulder-to-shoulder measurement. To alleviate this situation a series of measurements have been made on both bay and ocean crabs, the results of which are included in this report.

It may be wise to define a few terms especially what is meant by point-to-point measurements and shoulder-to-shoulder measurements. Point-to-point measurements are taken at the widest possible distance across the back of a crab which is, because of anatomical structure, the distance from the tip of the tenth tooth on the left to the tip of the tenth tooth on the right. Shoulder-to-shoulder measurement is

the distance across the back immediately in front of the tenth teeth (or points), this measurement always being shorter unless the crab has sustained some injury and had the points broken off which is found to be true in not too few cases. Measurements on crabs such as these are not included in the data in this report. There were about twenty such instances.

It was thought another end could be attained by this comparison of measurements and that was the possibility of their being a racial difference between bay and ocean crabs. (There are other racial measurements also being tested at this time at the Newport lab.) With the foregoing thoughts in mind, data was grouped from Tillamook Bay, Yaquina Bay, Netarts Bay, and ocean crabs from off the Alsea as shown in figures 5, 6, and 7. Both measurements were taken on each crab handled and recorded. To give an example, for each crab measuring 160 mm. shoulder to shoulder there were corresponding point-to-point measurements. The corresponding point-to-point measurements were averaged and plotted against the shoulder-to-shoulder measurement of 160 mm., this giving one point on the graph. This was done for the width range found on the graphs.

To make a straight line graph the slope was first found by the following method:

$$\text{Slope} = \frac{\text{Total Pt. width}}{\text{Total shoulder width}}$$

Multiplying this slope by the limits of the data a straight line was substituted having a given slope. This was the method employed in all of the graphs included. (A more accurate but time consuming method would be to find the line of regression statistically.) The averaged raw data is also shown for each graph as represented by the more jagged line.

The individual straight-line graphs for three bays and the Alsea crabs are plotted on one graph to show comparison among bays and also between bay and ocean crabs. (See figure 8)

The original width comparisons as given at the July 22 hearing of this year are listed below:

Back Width		Point Width	
mm.	inches	mm.	inches
144.6	5 11/16	152.5	6
158.8	6 1/4	167.5	6 5/8

These comparisons are entirely within the limits of the data given in this report and are correct for the sample from which they were taken. However, as the graphs indicate there appears to be a considerable variation, possibly natural variation, between populations. Therefore, it cannot be stated that the original figures (see table) would hold true for another sample even from the same area. In fact, indications are that an over-all set comparison ratio (pt vs shoulder ratio) cannot be set up. More samples are needed before a definite conclusion can be reached.

It appears that ocean crabs may have shorter points than do bay crabs (see figure 8), about 3 mm combined or 1½ mm per point.

It also appears that there might even be variation among the respective bays of Oregon. Consistent sampling and larger samples will either prove or disprove this statement.

Conclusions:

1. The original point-to-point shoulder-to-shoulder comparative measurements were correct for the sample for which they represent but indications are that perhaps no set comparison ratio between these two

measurements can be made.

2. From the meagre data on hand and the graphs enclosed, indications are that bay crabs may have longer points than do ocean crabs.

3. Separate populations (if they exist) for the bays may vary among themselves in the point-to-point shoulder-to-shoulder measurement ratio.

4. All these figures given need amplification before any hard and fast statement can be made concerning this data.

Early Growth Studies of Cancer Magister

On May 26, 1948 a number of very small crabs in various post-larval stages were obtained from the Alsea area, these young crabs being picked from the pots in conjunction with the larger crabs. All were given a specimen number and placed in individual bowls where a daily watch on condition, water changing, sheds, food, etc., was given. Although the data obtained is admittedly open to the criticism of unnatural conditions it is felt that the data is valuable for comparison with any future information that may be obtained. It has also proved interesting to compare these figures with those of MacKay (1942) which are listed here in table form as a comparison with the Newport figures. This table gives time in days between sheds of the various post-larval stages.

MacKay's Data*		Newport Data	
post-larval stage	size in mm.	post-larval stage	size in mm.
1st	5 mm	1st	no data
2nd	7.5 mm	2nd	7.4 mm (12 figs.)
3rd	9.0 mm	3rd	10.4 mm (13 figs.)
4th	12.5 mm	4th	12.8 mm (10 figs.)
5th	18.0 mm	5th	16.3 mm (8 figs.)
6th	no figures	6th	18.9 mm (5 figs.)
		7th	22.0 mm (1 fig.)

* MacKay's figures are as we interpreted his graphs.

MacKay's figures on size were not chosen from the instar duration study as were the Newport figures, but rather from width frequencies of

small crabs taken at various time intervals. MacKay groups Newport's fifth and sixth larval stages into one group, group 5. Newport data shows two groups, which might be accounted for by slowing of growth due to captivity. However, MacKay's graph showed an undefined peak for group 5 which could lead to a possible error on his part in interpretation of the graph.

The graph in figure 9 shows the Newport findings in concise form by comparing the number of days from the beginning of the third instar (the time at which complete information was available) to the end of the seventh instar with the width of the crabs during the respective instars. Growth of the young crabs is thus followed through a period of 129 days.

To date our figures are complete to October 8, 1948. As a number of crabs are still being held, the data on hand will be added to as each molt takes place. During the 1948-49 crab tagging program it is hoped a new group of post-larval form crabs may be obtained to strengthen the information already gathered.

Bibliography

MacKay, Donald D. G.
1942. The Pacific edible crab, Cancer magister. Fisheries Research Board of Canada, Bulletin No. 62, Ottawa.

Cancer magister - Egg Sampling

A considerable number of observations and samples were taken on the female crabs encountered during the 1947-48 tagging in the Astoria area. This work was all conducted from an otter trawl boat in the area just north of the mouth of the Columbia River. The majority of the data was worked up during the summer of 1948 by Mr. Grant Rea at this laboratory.

Females carrying eggs

On November 21, 1947 one female out of a total of seven crabs was taken in 75 to 80 fathoms off North Head. This female was in the act of shedding and had no eggs.

On December 5, a total of 145 crabs taken in 40 - 50 fathoms WNW of North Head contained one female without eggs (width 105 mm) and four with eggs (widths 147, 148, 152 and 165 mm).

On December 6, a total of 114 crabs taken in 30-35 fathoms WbN North Head contained eight females, four with eggs (widths 144, 146, 153 and 156 mm) and four without eggs (widths 107, 138, 142 and 143 mm).

Random samples of the crabs as they came up in the drags on January 25 and 26, 1948 gave the following:

Date	Depth	No. Males	No. Females	F W/eggs	F WO/eggs	F W/eggs gone
Jan. 25	23 fth.	29	280	87	140	53
Jan. 25	21 fth.	12	156	40	88	28
Jan. 25	38 fth.	52	249	17	16	216
Jan. 26	37 fth.	43	62	34	15	13
	Totals	136	747	178	259	310

Total crabs ——— 883

All drags were in the area west of North Head. The figures listed as "eggs gone" refer to the crabs that obviously had been carrying eggs (remnants, or general "black" remnant coloration) but no longer had them. Time did not permit measuring the above crabs but no apparent size differences were noted between groups.

The totals above may be expressed in percentages as:

15.4 per cent of all the crabs were males

84.6 per cent of all the crabs were females

Considering the females only:

23.8 per cent were carrying eggs

41.5 per cent had carried eggs

or 65.3% either were carrying or had carried eggs

34.7% showed no visible signs of eggs

Size and number of eggs carried

The percentage of the total eggs carried on each appendage was calculated so figures could be obtained on numbers of eggs carried by calculating from one standard appendage only without having to take and preserve the entire abdomen.

Seven entire abdomens were preserved in ~~Bouins~~ formalin December 5 and 6, 1947. These were then individually separated as to the eight different pleopods (four on each side). After draining the excess ~~alcohol into which they had~~ formalin

~~been transferred from Bouins,~~ the volumes in milliliters were derived by displacement in ~~alcohol~~ water in 100 ml graduates. The results are as shown:

	Pleopod #1		Pleopod #2		Pleopod #3		Pleopod #4		Abdomen
Abdomen	Left	Right	Left	Right	Left	Right	Left	Right	Total
1-2	9.9	9.0	9.0	10.0	9.0	10.0	6.0	5.0	68.9
1-1	5.0	6.6	7.7	10.0	12.5	0.8	11.9	11.0	60.5
2-1	6.4	3.0	5.5	5.2	0.0	3.0	0	1.9	33.0
3-1	20.0	20.0	20.0	5.0	15.0	15.0	10.0	10.0	115.0
1-3	5.0	6.5	5.0	5.0	1.0	5.0	0	360	37.5
2-3	13.0	13.0	12.0	4.0	13.0	11.0	7.0	7.0	80.0
3-3	1.0	1.0	7.0	6.0	5.0	5.0	4.0	4.0	33.0
Totals	65.3	64.1	67.2	45.2	55.5	50.8	38.9	42.3	432.9
Average of Rt & Left	64.7		57.7		53.2		40.9		61.8*
% of Total	14.9%		13.3%		12.3%		9.4%		

- *Average volume of an entire abdomen.

It should be noted that the percent of totals figures are for an individual pleopod, that the total of both right and left #1 pleopods, for example, is 29.8%.

The pleopods were numbered from anterior to posterior, #1 being the most anterior on the body.

The #1 pleopod, right side, was selected as a standard appendage to be taken.

To determine how much of the volume was due to eggs only and how much to the supporting shaft of the pleopod the eggs were carefully stripped from each shaft of an entire abdomen and the volumes of the shafts determined as:

Right	#1	-	0.9 ml
"	#2	-	0.5 ml
"	#3	-	0.3 ml
"	#4	-	0.2 ml
Left	#1	-	0.2 ml
"	#2	-	0.3 ml
"	#3	-	0.3 ml
"	#4	-	0.1 ml
Total		-	2.8 ml
Average		-	0.35 ml

Considering the fluctuations between shafts and the extremely small volumes involved, the resulting difficulty in estimating tenths of mls., it was decided to continue using all shafts from an abdomen together and averaging the results as:

8 shafts, abdomen #1 - average - 0.25 ml.

6 shafts, abdomen #2 - average - 0.33 ml.

8 shafts, abdomen #3 - average - 0.20 ml.

Total	0.78 ml.
Average	0.26 ml.

In view of the small volume of the shafts as against the large volume of the eggs, it was felt a sufficiently accurate factor would be 0.3 ml per shaft. This should also safely include the microscopic attachment hairs between the eggs and shafts. A standard volume for shafts was therefore set as 2.4 ml. per abdomen.

To determine the number of eggs contained per ml. volume the diameter of the eggs was first determined using an ocular micrometer with a compound microscope. One hundred eggs were measured from each of eight abdomens, the data being kept separate by consecutive groups of 25 measurements. The data showed that measuring 75 random eggs from an abdomen gave valid results, i.e., the results of 75 were only slightly

more consistent than those of 50 measurements and with no noticeable increase in consistency by measuring 100. However, for all work here, samples of 100 were measured as a minimum number.

The results of three abdomens preserved in Bouin's were:

	Range	Average
Abdomen 1	42-49	46.16
" 2	40-49	47.58
" 3	40-49	45.80
All abdomens	40-49	46.51

The figures given are micrometer units, each unit - 12 microns, with the range being the extremes encountered.

The results of five abdomens preserved in formalin were:

	Range	Average
Abdomen 1	39-45	42.58
" 2	37-44	41.40
" 3	39-46	43.03
" 2A	40-45	42.61
" 3A	38-43	41.09
All abdomens	37-46	42.20

Average diameter Bouin's material - 558 microns.

Average diameter Formalin material - 506 microns.

By calculating for the volume of a sphere ($V = 4/3\pi R^3 = 4.189 R^3$) the volumes were obtained as:

Bouin's material - 0.000091 ml/egg
- 11,000 eggs/ml

Formalin material - 0.000068 ml/egg
- 14,600 eggs/ml

The eggs/ml are rounded to the nearest 100.

The number of eggs carried per crab was then found by dividing the volume in ml of the standard number one appendage preserved by the standard figure of 14.9 per cent, the percentage of the total volume as carried on this pleopod. This gave the volume of all the eggs and shafts on that abdomen from which the shaft volume of 2.4 ml was subtracted

giving volume of eggs only. (Since this was the sequence in which the standard percentages were obtained it is necessary to follow the same in calculating for an unknown; i.e., subtract 2.4 ml from the calculated abdomen total rather than subtracting 0.3 ml from the number one appendage and dividing that by 14.9 per cent. The latter gives a slightly erroneous answer since the comparative volume ratios for all appendages are not equal.)

Using the above proceedure the number of eggs carried by seven females preserved in formalin December 5, 6, 1947 taken in 30-50 fathoms off North Head gave the following:

	Back Width of Crab	No. of eggs
	120-129	1,0
	144 mm	482,000
	146 mm	548,000
	147 mm	1,679,000
	148 mm	1,006,000
	152 mm	956,000
	156 mm	1,285,000
	165 mm	482,000
Average	151 mm	868,000

A total of 56 abdomens were sampled and preserved January 25-26, 1948 from 21 to 37 fathoms of water off North Head. These had been preserved in Bouin's then transferred into alcohol so all volume determinations were made in alcohol. It had not been possible to isolate the back widths according to sample so all that can be given is the average for all 56 crabs. Average number of eggs carried - 453,000.

Observations were made while working the material up to attempt to find some simple method of determining the extent of development of the eggs. Although different groups of eggs were seen to be in varying developmental stages, it was impossible to set any simple criteria for expressing the stage except as comparing to another group on the basis of general appearance. To do so accurately will necessitate the

development of some special technique. The only simple method observed was the color of the entire egg mass. In general the eggs start as a bright, light orange and gradually darken to a dark red in color. Observations also failed to show any obvious difference in rate of development of the eggs depending upon their location in the mass.

COCKLE CLAM GROWTH STUDIES

Cockle clams, Cardium corbis, from Yaquina Bay were collected at the Newport lab and sorted into size groups over a period of three days. While awaiting measurements and more specimens the clams were held in the live box at the lab during which time a wire cage was constructed which was to be lowered in the bay behind the lab. Measurements of the frame of the cage were approximately 36" x 24" x 6" over which was stretched 1/6 inch galvanized hardware cloth. On June 24, 1948 five groups of cockles were placed in the cage and lowered into the bay. Composition of the five groups were as follows:

Group I (Unmarked)
Average rib length* of 5 individuals —— 14.4 mm
Ranged fro 13-17 mm.

Group II (Marked with file on right side)
Average rib length of 7 individuals —— 24.0 mm
Ranged from 20-28 mm.

Group III (Marked with file on left side)
Average rib length of 6 individuals —— 32.7 mm
Ranged from 31-35 mm.

Group IV (Notch across both umbos)
Average rib length of 5 individuals —— 40.2 mm
Ranged from 38-43 mm.

Group V (Unmarked)
Average rib length of 7 individuals —— 46.6 mm
Ranged from 44-49 mm.

*Rib length is defined as the distance from the top of the umbo to the end of the longest rib, sometimes designated as the width of the shell, or the depth of the clam.

Individuals within a group were arbitrarily selected on the size differences above.

Three inspections of the cage for mortality, condition of clams, etc., were made on July 2, July 27, and August 10 respectively. Five dead clams were removed during this period these being from the following groups: July 2: One specimen from Group I, and two specimens from Group IV; July 27: One specimen from Group II; August 10: One specimen from Group II. Mortality did not appear to be selective of any one group.

On the July 2 inspection the wire cage showed definite signs of torn mesh which were attributed to rock crabs, Cancer productus, which are prevalent around the dock. These signs were noticed in increasing severity until September 27, the last inspection, during which time the crabs had succeeded in tearing a hole in the cage and had destroyed all the remaining clams inside.

The August 10 inspection included re-measurements of all specimens and growth could definitely be seen with the naked eye.

Group	Rib L June 24	Rib L Aug. 10	Growth mm
I	14.4	21.0	6.6
II	24.0	28.6	4.6
III	32.7	35.3	2.6
IV	40.2	44.0	3.8
V	46.6	48.4	1.8

This remarkable growth was accomplished in 47 days. A differential in growth is evident among the groups, the smaller individuals appearing to grow faster in proportion to the larger ones. Group IV does not fit into the pattern but this might be explained by the fact that two specimens were missing having been found dead July 2.

Check or growth rings could easily be seen at the August 10 inspection.

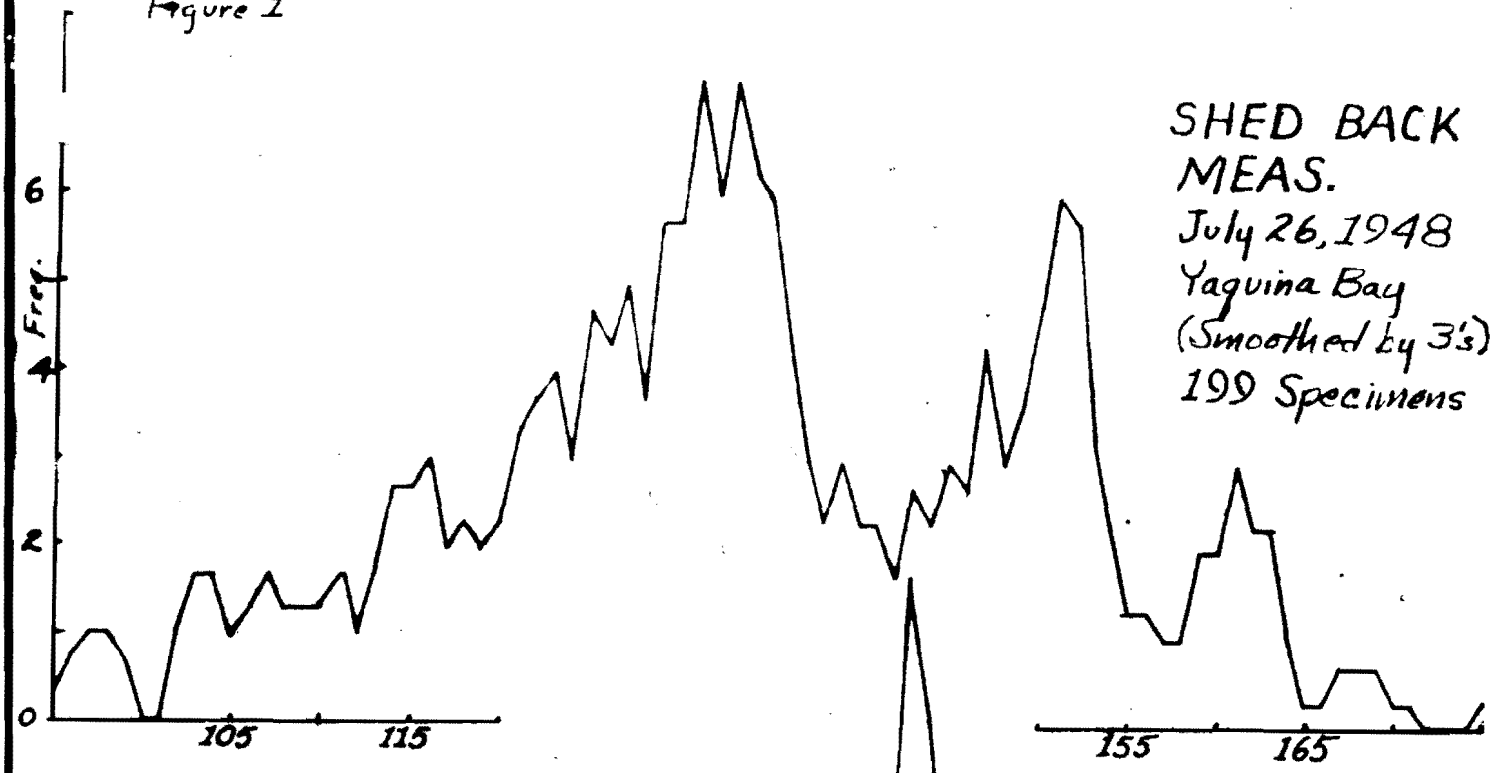
Whether they were formed by a change of habitat or by the season or whatever the cause is not known.

With the coming of spring minus tides, more specimens will be obtained and a stronger cage constructed to continue this interesting growth experiment on the cockle clam.

Roger Tollefson,
Lowell D. Marriage,

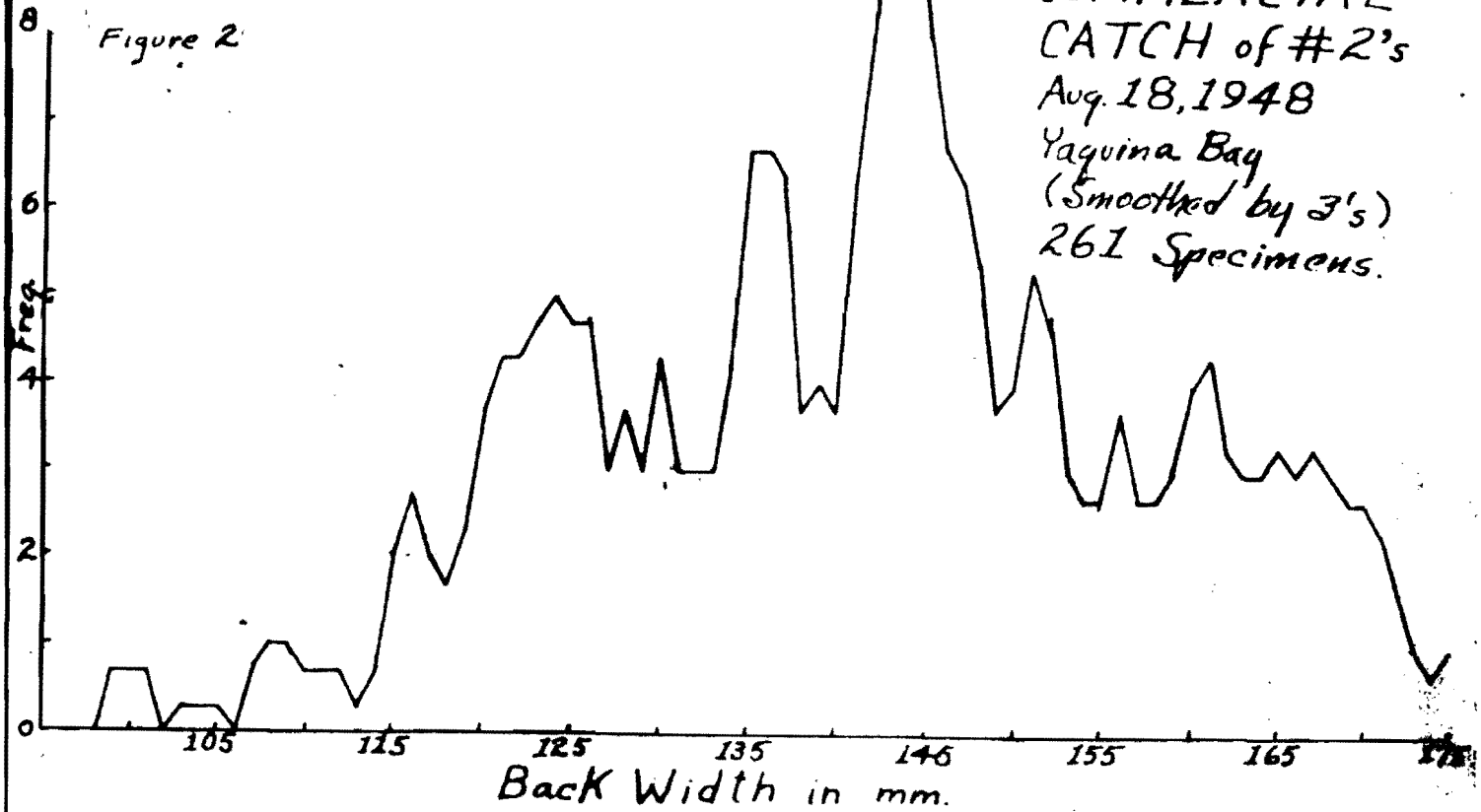
Biologists.

Figure 1



SHED BACK MEAS.
July 26, 1948
Yaquina Bay
(Smoothed by 3's)
199 Specimens

Figure 2



COMMERCIAL CATCH of #2's
Aug. 18, 1948
Yaquina Bay
(Smoothed by 3's)
261 Specimens.

Figure 3

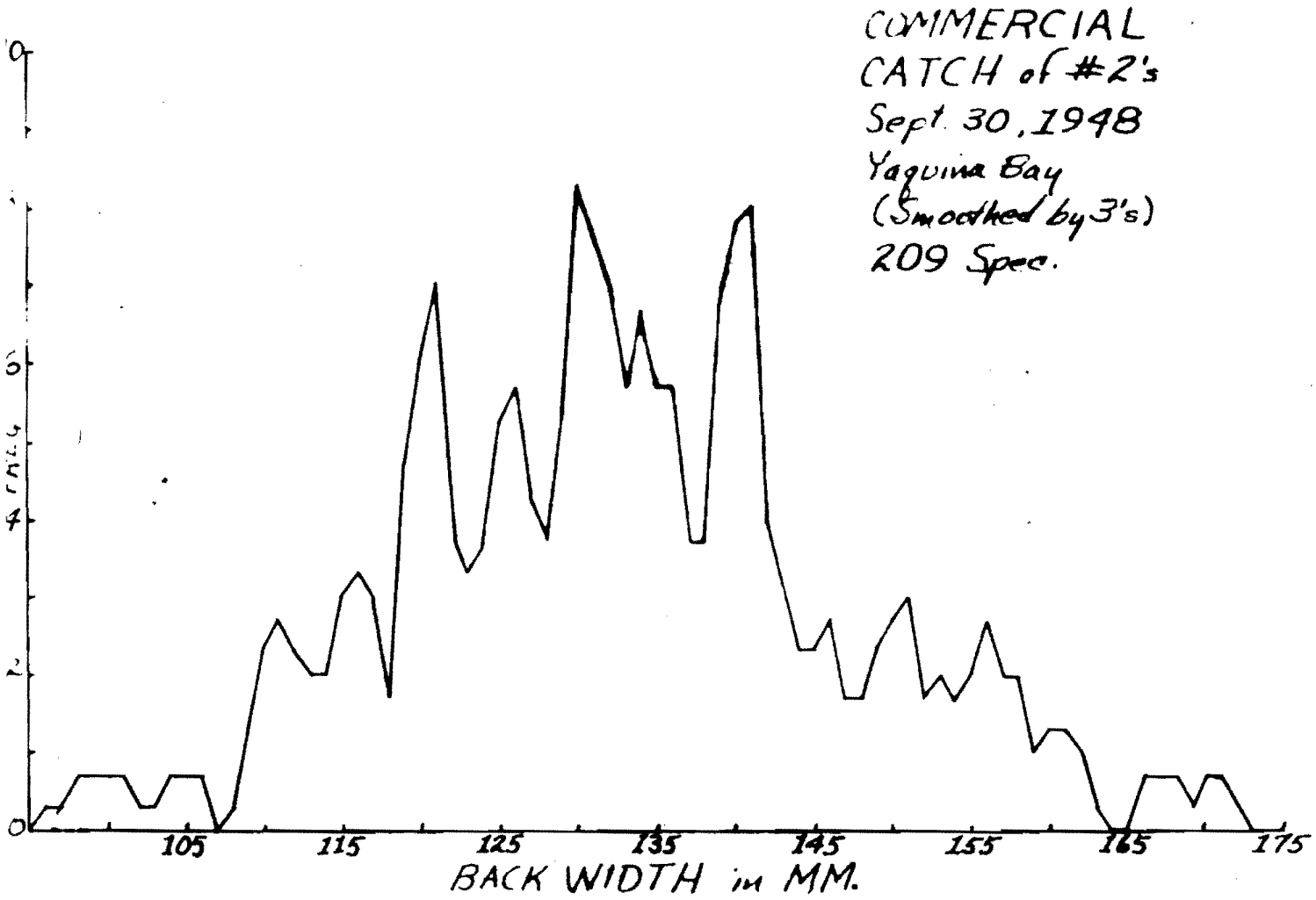

COMMERCIAL
CATCH of #2's
Sept. 30, 1948
Yaquina Bay
(Smoothed by 3's)
209 Spec.
0
2
4
6
105
115
125
135
145
155
165
175
BACK WIDTH in MM.

Figure 4

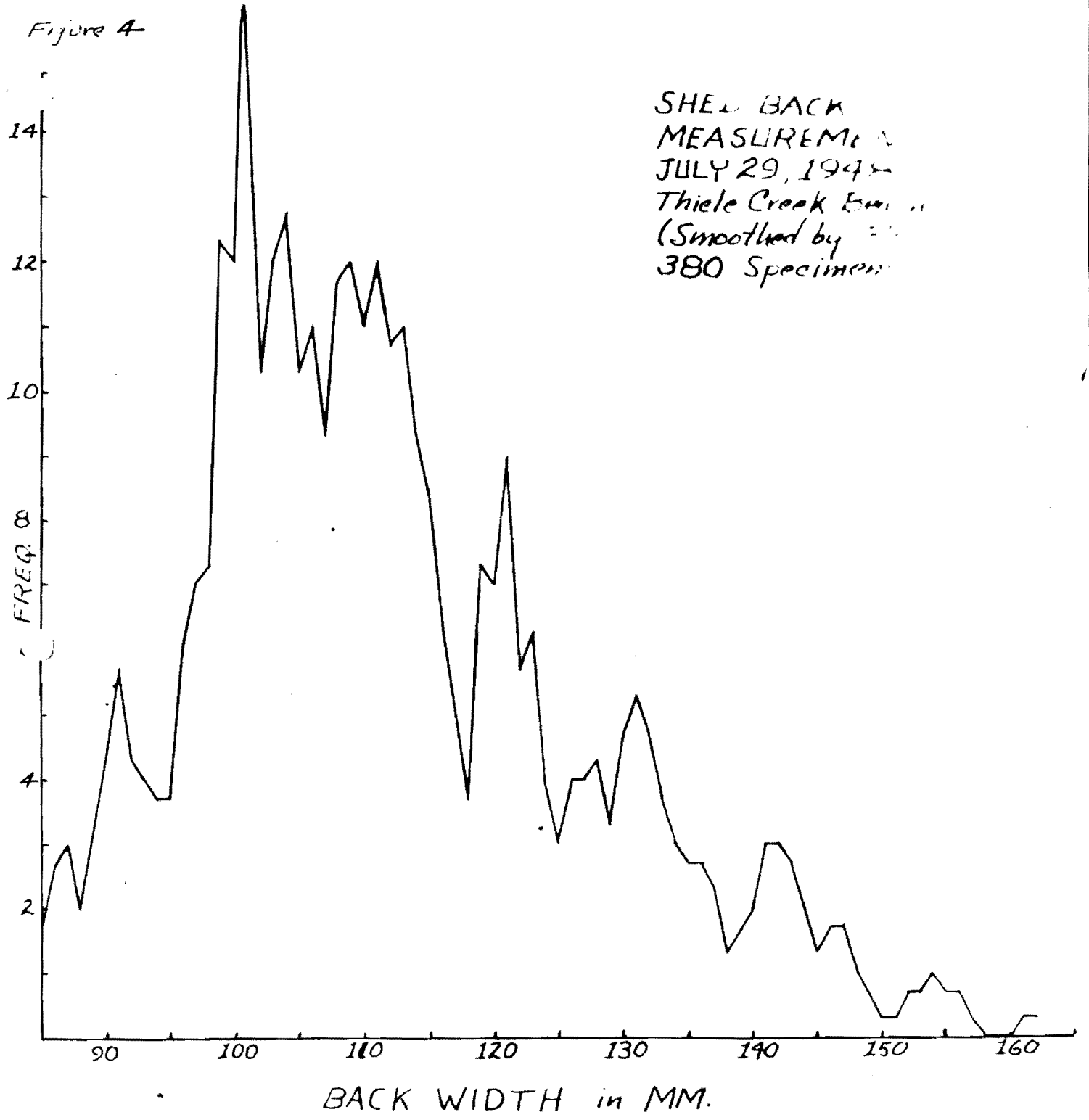

SHELL BACK
MEASUREMENTS
JULY 29, 194-
Thiele Creek
(Smoothed by
380 Specimens
14
12
10
8
FREQ.
4
2
90
100
110
120
130
140
150
160
BACK WIDTH in MM.

Figure 5

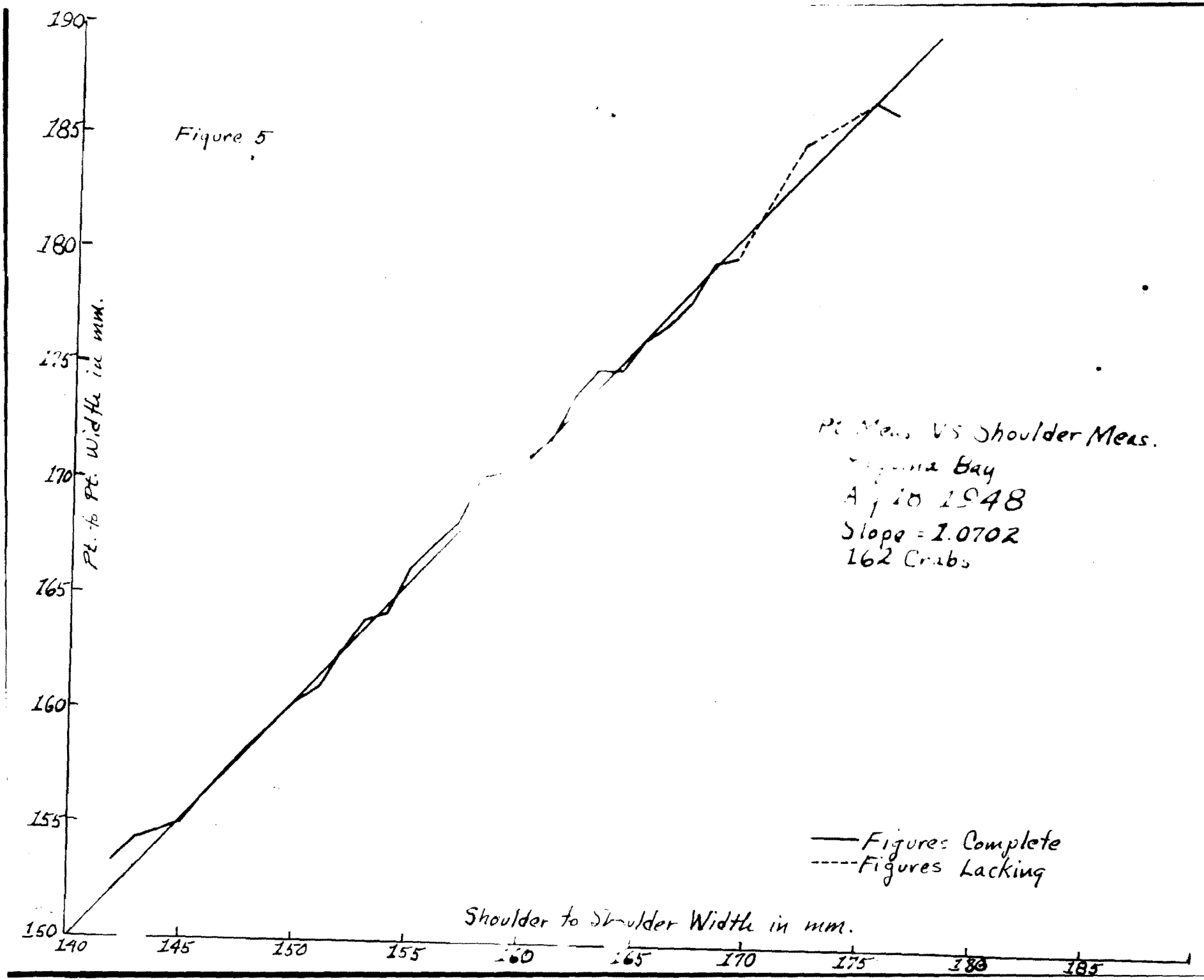

190
185
180
175
170
165
160
155
150
Pt. to Pt. Width in mm.
Pt. Meas. Vs Shoulder Meas.
Figure Bay
April 1948
Slope = 1.0702
162 Crabs
Figures Complete
Figures Lacking
Shoulder to Shoulder Width in mm.
140
145
150
155
160
165
170
175
180
185

Figure 6

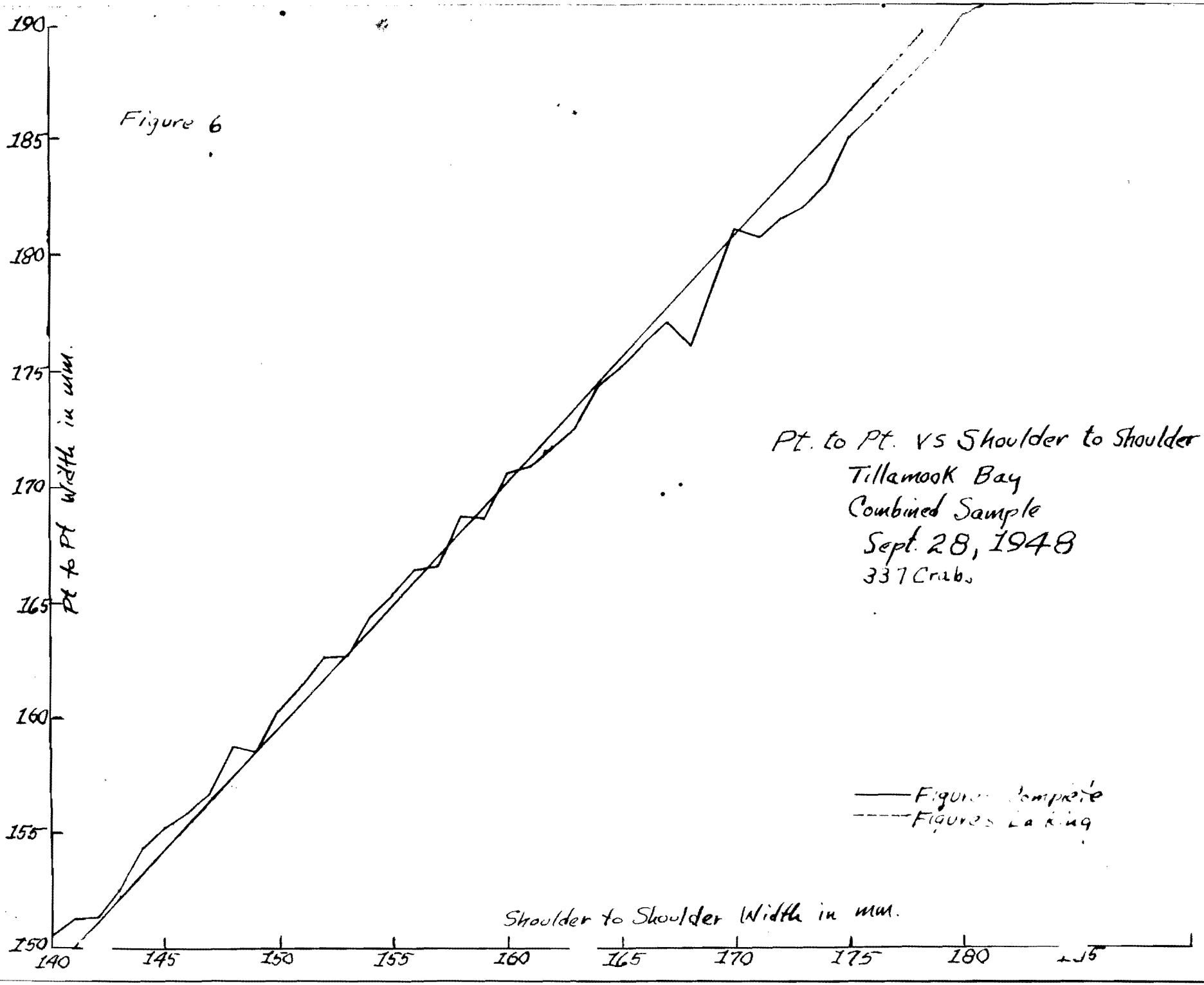

190
185
180
175
170
165
160
155
150
Pt to Pt Width in mm.
140
145
150
155
160
165
170
175
180
Shoulder to Shoulder Width in mm.
Pt. to Pt. vs Shoulder to Shoulder
Tillamook Bay
Combined Sample
Sept. 28, 1948
337 Crabs
Figures Complete
Figures Lacking

Figure 7

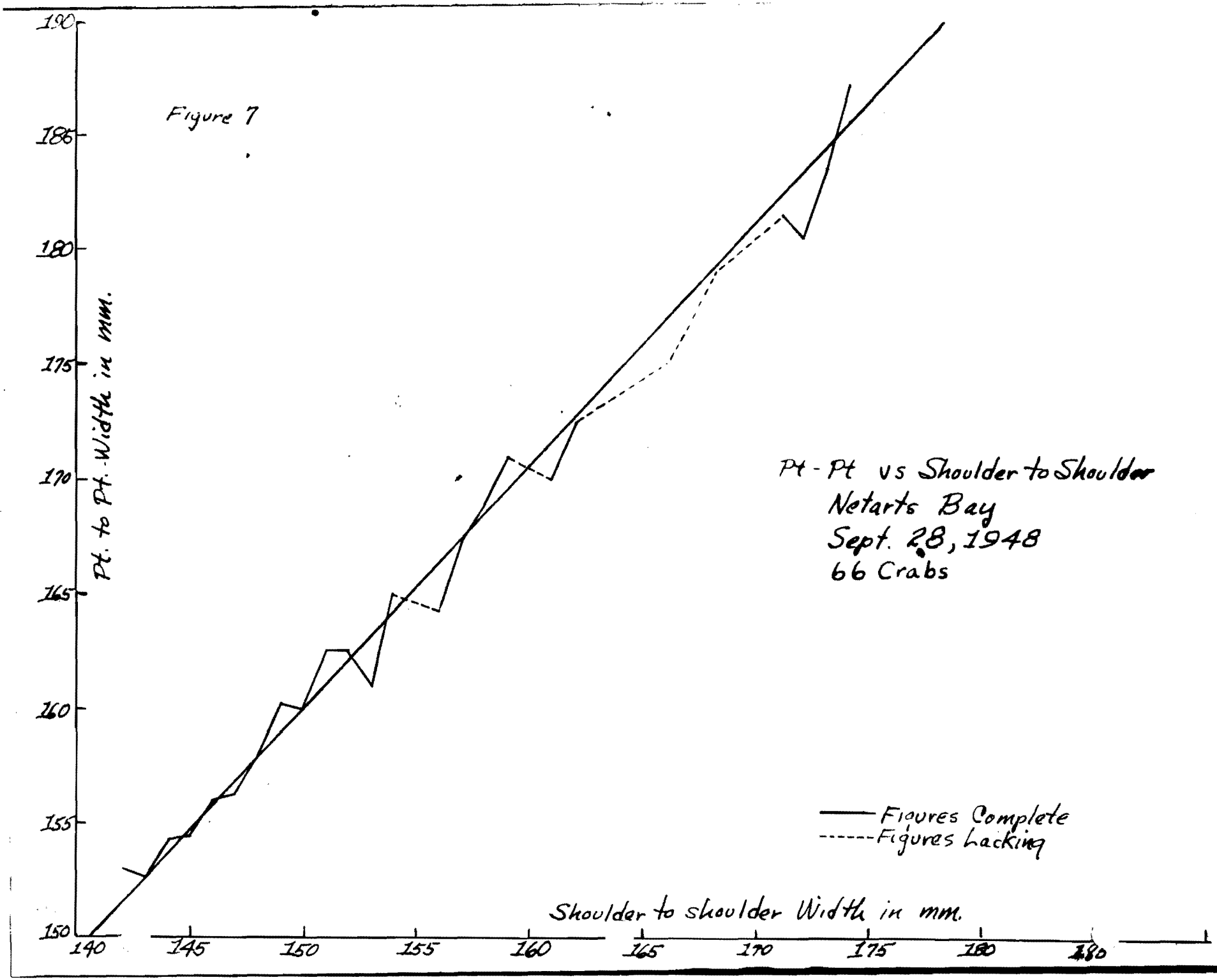

190
185
180
175
170
165
160
155
150
Pt. to Pt. Width in mm.
140
145
150
155
160
165
170
175
180
180
Shoulder to shoulder Width in mm.
Pt - Pt vs Shoulder to Shoulder
Netarts Bay
Sept. 28, 1948
66 Crabs
Figures Complete
Figures Lacking

Figure 8

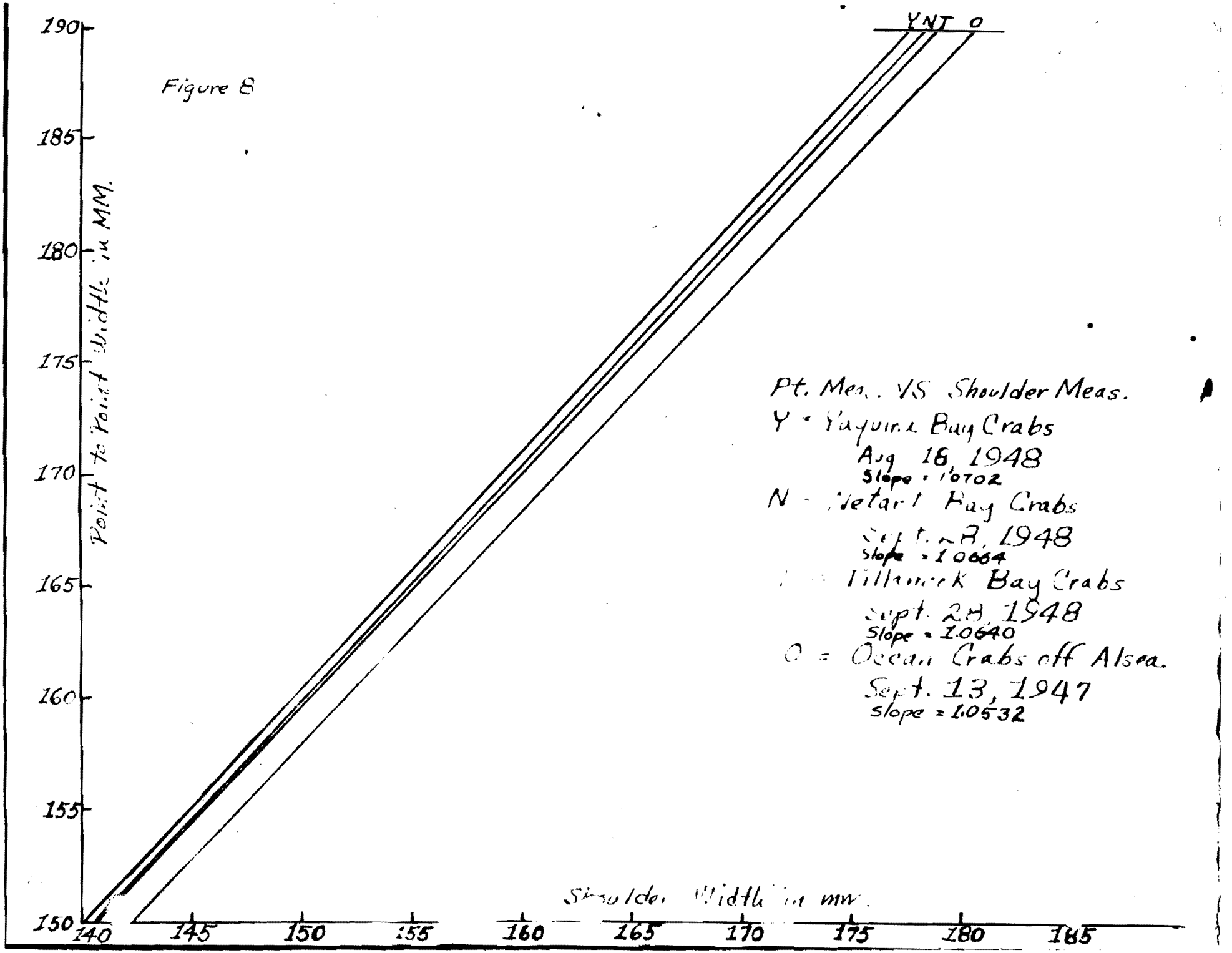
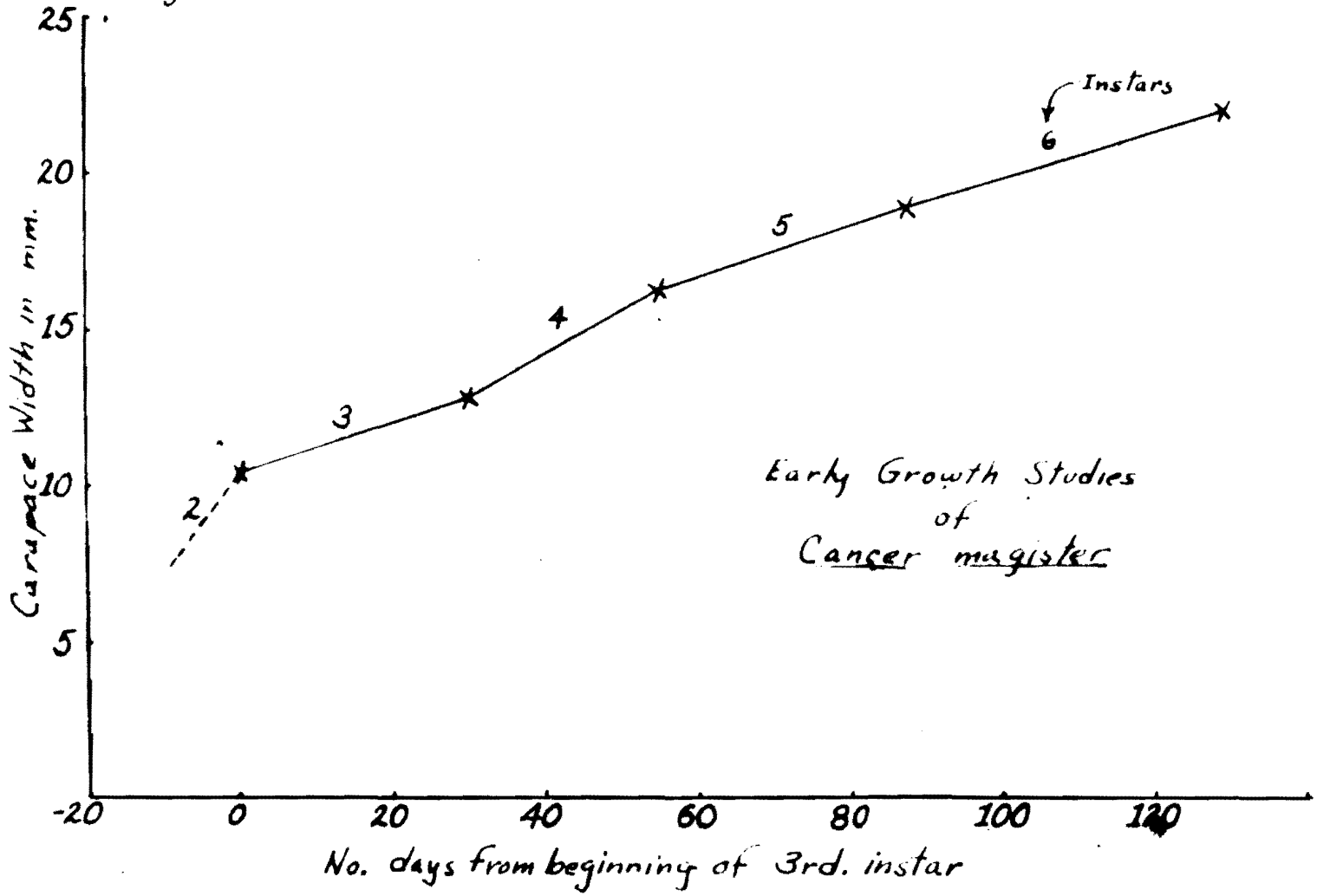

YNT O
190
185
180
175
170
165
160
155
150
Point to Point Width in MM.
140
145
150
155
160
165
170
175
180
185
Shoulder Width in mm.
Pt. Mea. VS Shoulder Meas.
Y = Yaquina Bay Crabs
Aug 18, 1948
Slope = 1.0702
N = Netarts Bay Crabs
Sept. 28, 1948
Slope = 1.0664
T = Tillamook Bay Crabs
Sept. 28, 1948
Slope = 1.0640
O = Ocean Crabs off Alsea
Sept. 13, 1947
Slope = 1.0532

Figure 9


Instars
2
3
4
5
6
Early Growth Studies
of
Cancer magister
Carapace Width in mm.
25
20
15
10
5
-20
0
20
40
60
80
100
120
No. days from beginning of 3rd. instar